
3 LUBRICATION SYSTEM

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3.1 OIL PAN

Perform the following procedures for removal and installation of the oil pan.

3.1.1 Oil Pan Removal

Remove the oil pan as follows:

1. Drain the engine oil. See Figure 3-1 for location of the drain plug. Discard the drain plug seal.

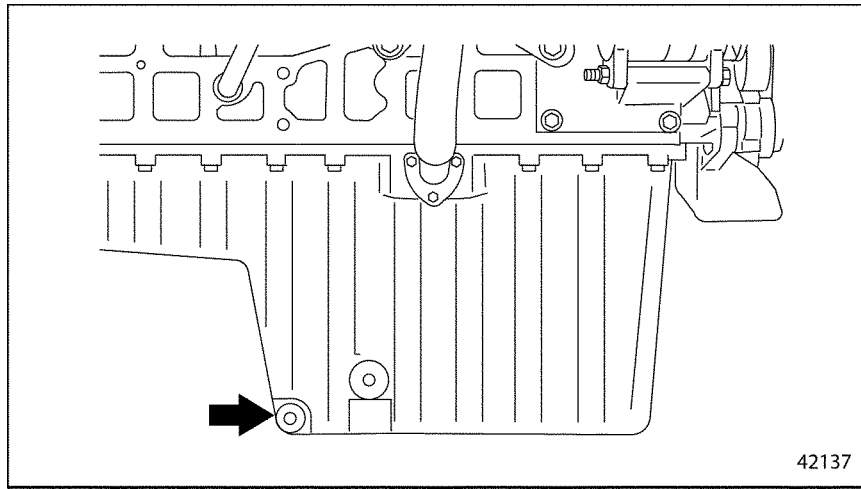


Figure 3-1 Engine Oil Drain Plug

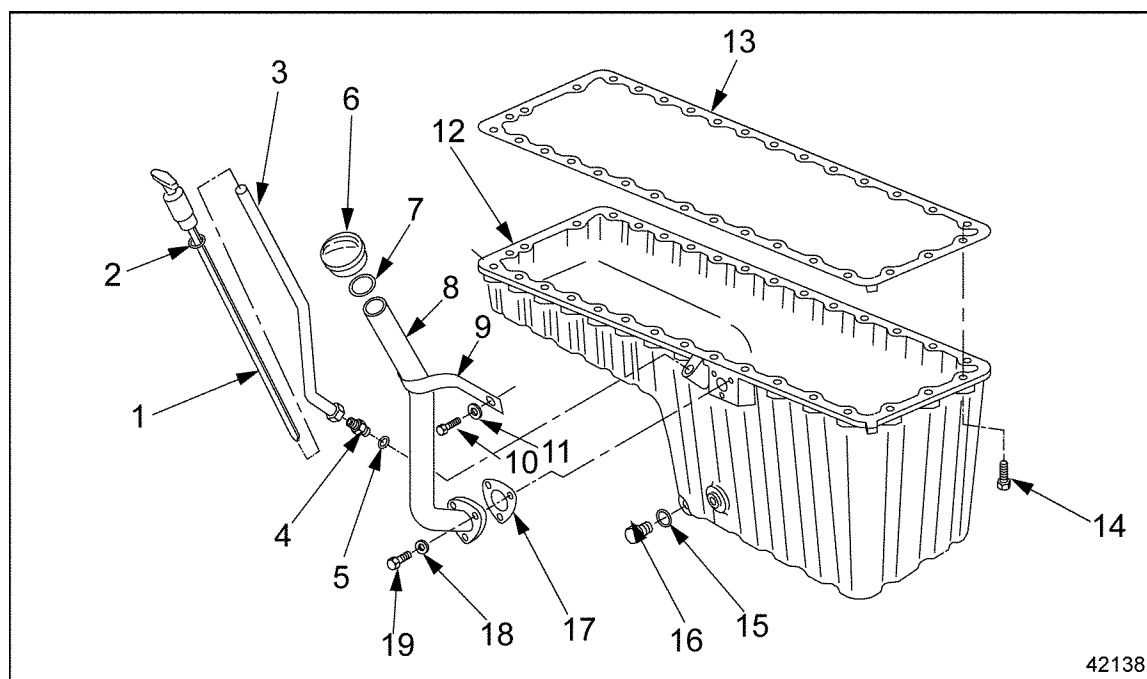
! WARNING:

PERSONAL INJURY

To avoid injury when removing or installing a heavy engine component, ensure the component is properly supported and securely attached to an adequate lifting device to prevent the component from falling.

2. Using a floor jack, jack up the vehicle and place it on stands located behind the front suspension.
3. Loosen all front suspension shackle bolts.
4. Remove the front spring bolts and shock absorber bolts. Using the floor jack, lower the axle to the ground.

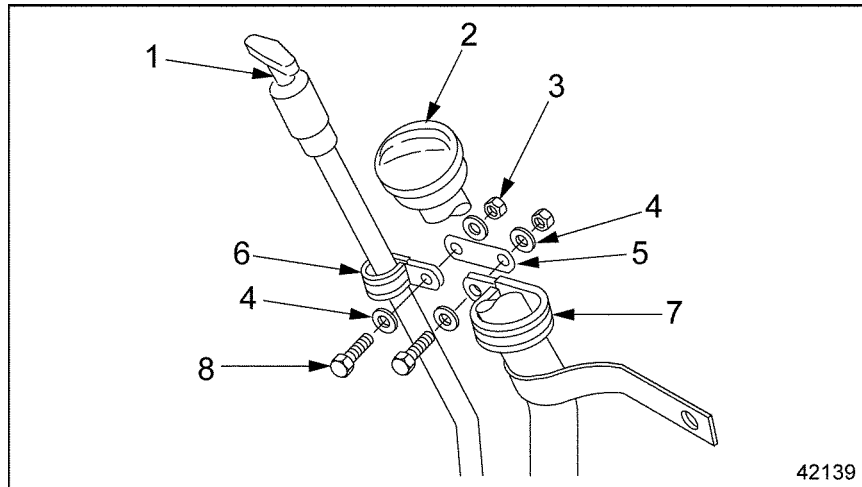
5. Remove the dipstick and dipstick O-ring. Discard the O-ring. See Figure 3-2.



- | | |
|----------------------------|-------------------------------|
| 1. Dipstick | 11. Fill Tube Retainer Washer |
| 2. Dipstick O-ring | 12. Oil Pan |
| 3. Dipstick Guide Tube | 13. Oil Pan Gasket |
| 4. Adaptor | 14. Oil Pan Bolt |
| 5. Adaptor Seal | 15. Drain Plug Seal |
| 6. Oil Fill Cap | 16. Oil Pan Drain Plug |
| 7. Oil Fill O-ring | 17. Fill Tube Gasket |
| 8. Oil Fill Tube | 18. Fill Tube Flatwasher |
| 9. Oil Fill Tube Retainer | 19. Fill Tube Bolt |
| 10. Oil Fill Retainer Bolt | |

Figure 3-2 Oil Pan Removal and Installation

6. Remove the connector and clamp attaching the dipstick guide tube to the oil fill tube. See Figure 3-3.



- | | |
|-----------------|------------------------|
| 1. Dipstick | 5. Connector |
| 2. Oil Fill Cap | 6. Dipstick Clamp |
| 3. Locknut | 7. Oil Fill Tube Clamp |
| 4. Flatwasher | 8. Bolt |

Figure 3-3 Standoff Bracket (exploded view)

7. Remove the dipstick guide tube, adaptor, and seal. Clean the guide tube and discard the seal. See Figure 3-2.
8. Remove the oil fill tube.
 - [a] Remove the bolt that fastens the oil fill tube retainer to the cylinder block.
 - [b] Remove the oil fill bolts and washers that fasten the oil fill tube to the oil pan. Save the bolts and washers.
 - [c] Remove and discard the gasket on the oil fill tube. Clean the contact surfaces of the fill tube and the oil pan, removing all traces of gasket material.
 - [d] Clean the oil fill tube.
9. Remove the oil pan from the cylinder block.
10. Remove and discard the oil pan gasket. Save the bolts.
11. Thoroughly clean the pan. Remove all traces of gasket material from the pan and from the block.

3.1.2 Oil Pan Installation

Install the oil pan as follows:

1. Position a new gasket on the cylinder block.

2. Install the pan on the block and tighten each oil pan bolt to 35 N·m (26 lb·ft). See Figure 3-4 for the tightening pattern. When all the bolts have been tightened, go back and re-tighten the four corner bolts (positions #1 through #4).

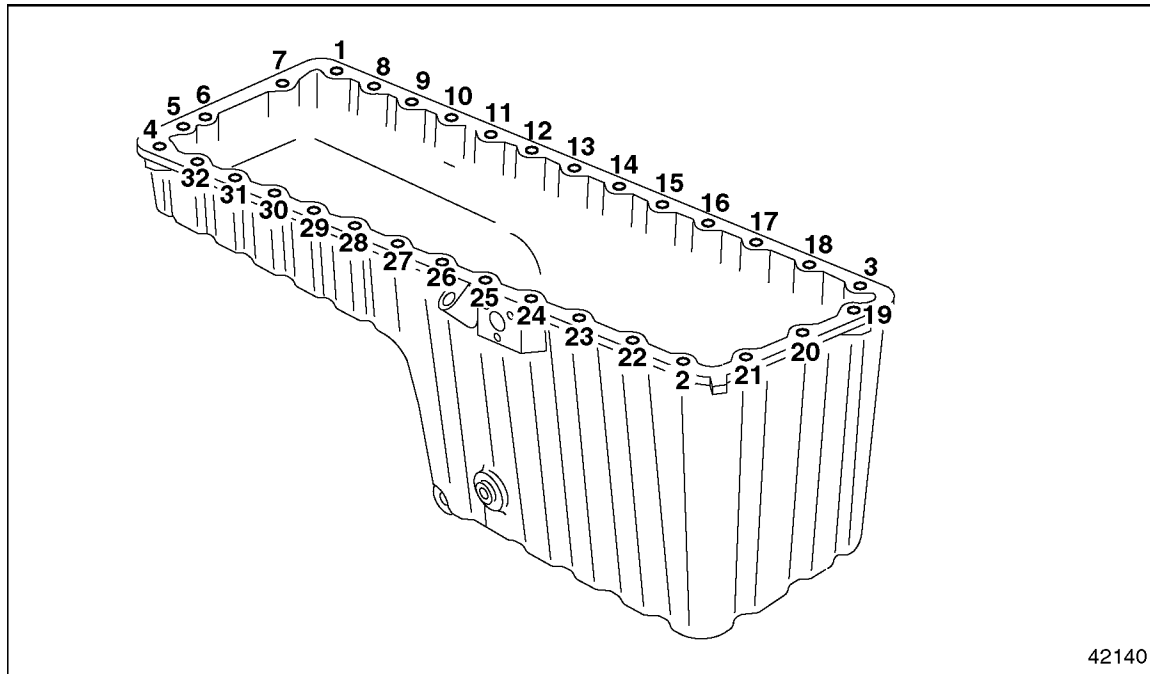
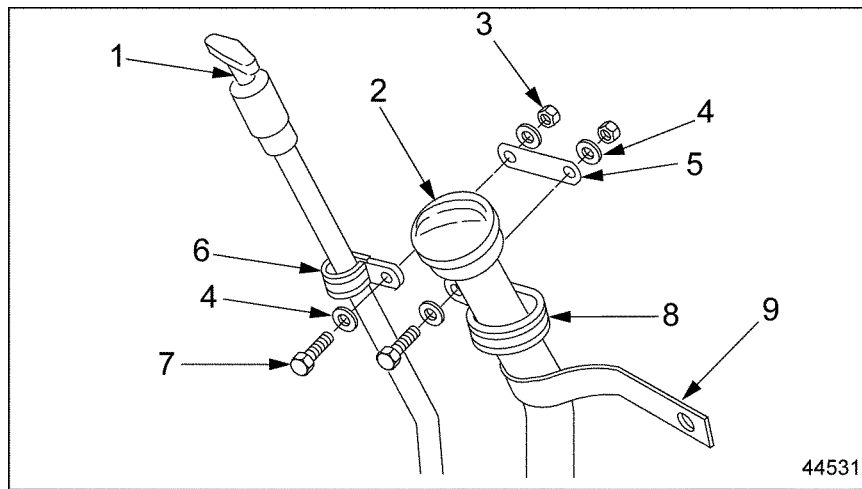


Figure 3-4 Oil Pan Bolt Tightening Pattern

3. Install the oil fill tube as follows: (See Figure 3-5.)



- | | |
|----------------------|---------------------------|
| 1. Dipstick | 6. Dipstick Clamp |
| 2. Oil Fill Tube | 7. Bolt |
| 3. Locknut | 8. Oil Fill Tube Clamp |
| 4. Flatwasher | 9. Oil Fill Tube Retainer |
| 5. Connector Bracket | |

Figure 3-5 Installing the Oil Fill Tube and Dipstick Guide Tube

- [a] Connect the oil fill tube clamp to the coolant inlet pipe using the oil fill tube clamp bolt. Tighten to 10 N·m (7 lb·ft).
 - [b] Position a new oil fill tube gasket on the oil pan. See Figure 3-2.
 - [c] Install the three oil fill tube bolts. Tighten each bolt to 25 N·m (18 lb·ft).
 - [d] Tighten the oil fill tube clamp bolt to 25 N·m (18 lb·ft).
 - [e] Replace the O-ring in the oil fill cap. See Figure 3-2.
- 4. Replace the adaptor seal on the adaptor. Install the adaptor on the oil pan. Tighten the adaptor to 50 N·m (37 lb·ft). See Figure 3-2.
 - 5. Install the dipstick guide tube on the adaptor and tighten it to 20 N·m (15 lb·ft).

NOTE:

Check the alignment between the dipstick guide tube and the oil fill tube. They must be parallel to each other.

- 6. Replace the O-ring on the dipstick.
- 7. Replace the seal on the oil drain plug. Install the oil drain plug on the oil pan. Tighten the drain plug to 80 N·m (59 lb·ft).

8. Install dipstick clamp, oil fill tube clamp, and connector bracket. Tighten to 10 N·m (7 lb·ft). See Figure 3-5.

NOTE:

Check the alignment between the dipstick guide tube and the oil fill tube. They must be parallel to each other.

9. Tighten the connector bracket locknuts until firm.

NOTE:

Recheck the alignment between dipstick guide tube and oil fill tube.

10. Fill the engine oil circuit. The correct oil fill capacity is listed in Table 3-4.
11. Using the floor jack, raise the axle until it is in position to install the spring bolts and shock absorber bolts. Install the front suspension.
12. Tighten the shackle bolts and adjust the suspension.
13. Remove the stands and lower the vehicle to the ground.

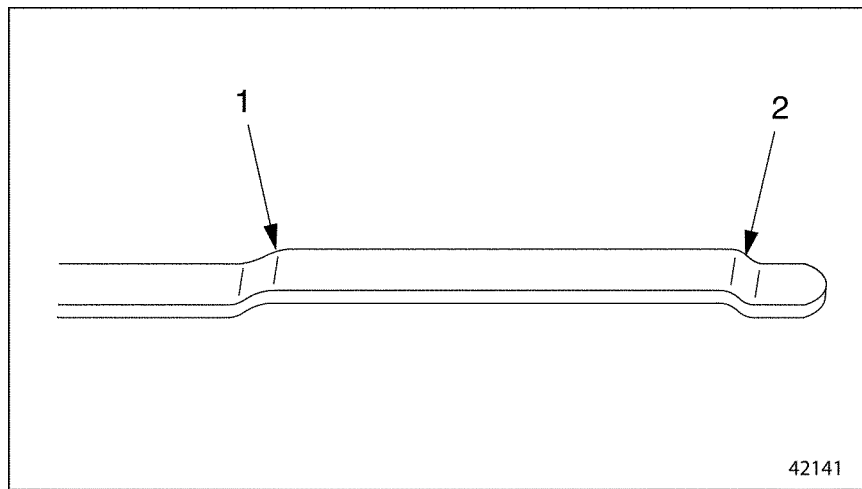
**WARNING:****PERSONAL INJURY**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- ☐ **Always start and operate an engine in a well ventilated area.**
- ☐ **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- ☐ **Do not modify or tamper with the exhaust system or emission control system.**

14. Start the engine and check for leaks.

15. Shut down the engine. Check the oil level and add oil if necessary. See Figure 3-6.



1. Maximum Fill Level

2. Minimum Fill Level

Figure 3-6 Oil Dipstick

NOTE:

Do not fill beyond the maximum fill level on the dipstick, since overfilling may result in high oil consumption.

3.2 PISTON OIL SPRAY NOZZLE(S)

Perform the following procedures for removal and installation of the piston oil spray nozzle.

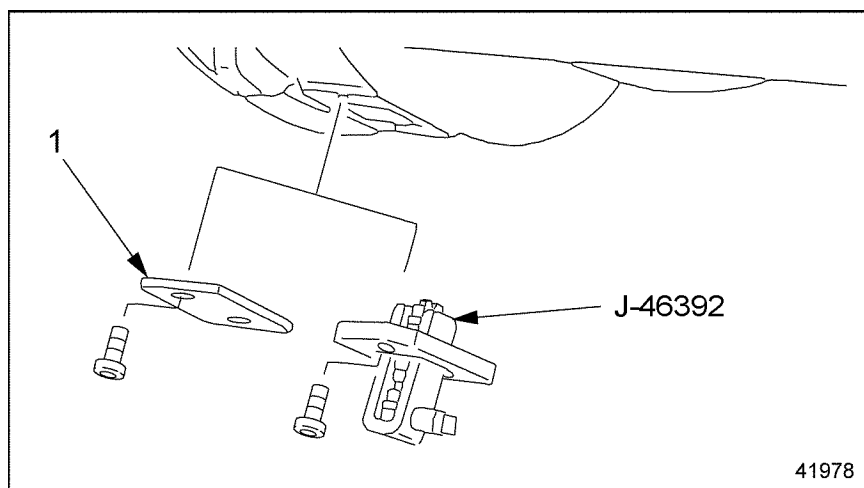
3.2.1 Piston Oil Spray Nozzle(s) Removal

Remove the piston oil spray nozzle(s) as follows:

NOTE:

These procedures refer to bolt-on piston oil spray nozzles only.

1. Remove the oil pan. Refer to section 3.1.1.
2. Remove the inspection cover on the flywheel housing and install the engine cranking tool (J-46167). See Figure 3-7. Rotate the crankshaft to gain access to the nozzle(s).



1. Inspection Cover

Figure 3-7 Installing the Engine Cranking Tool

3. Remove the hollow-core bolt that attaches each piston oil spray nozzle to the underside of the cylinder block. Remove the oil spray nozzle from the engine. See Figure 3-8.

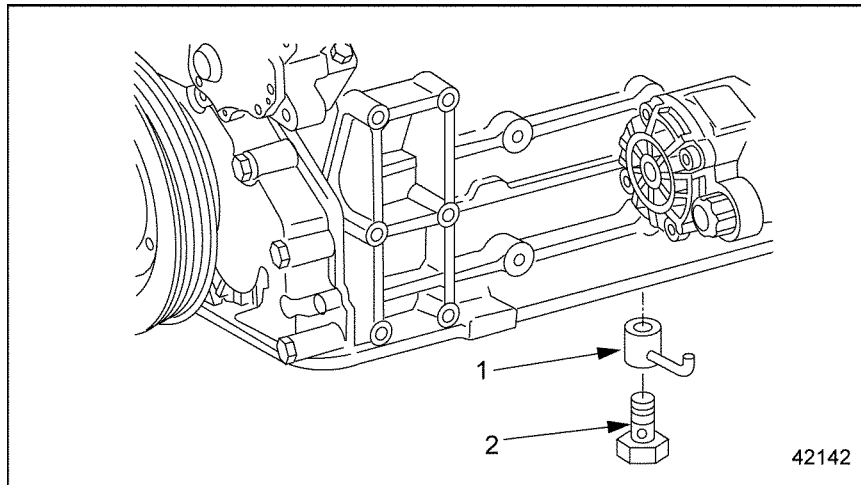


Figure 3-8 **Removing the Piston Oil Spray Nozzle(s)**

NOTE:

Piston cooling nozzle tool J-47301 is used to check the proper alignment of the piston oil spray nozzles for non-EGR and EGR engines built before March 2005. EGR engines built starting March 2005 **do not** use this tool. For identification of the oil spray nozzles see Figure 3-9.

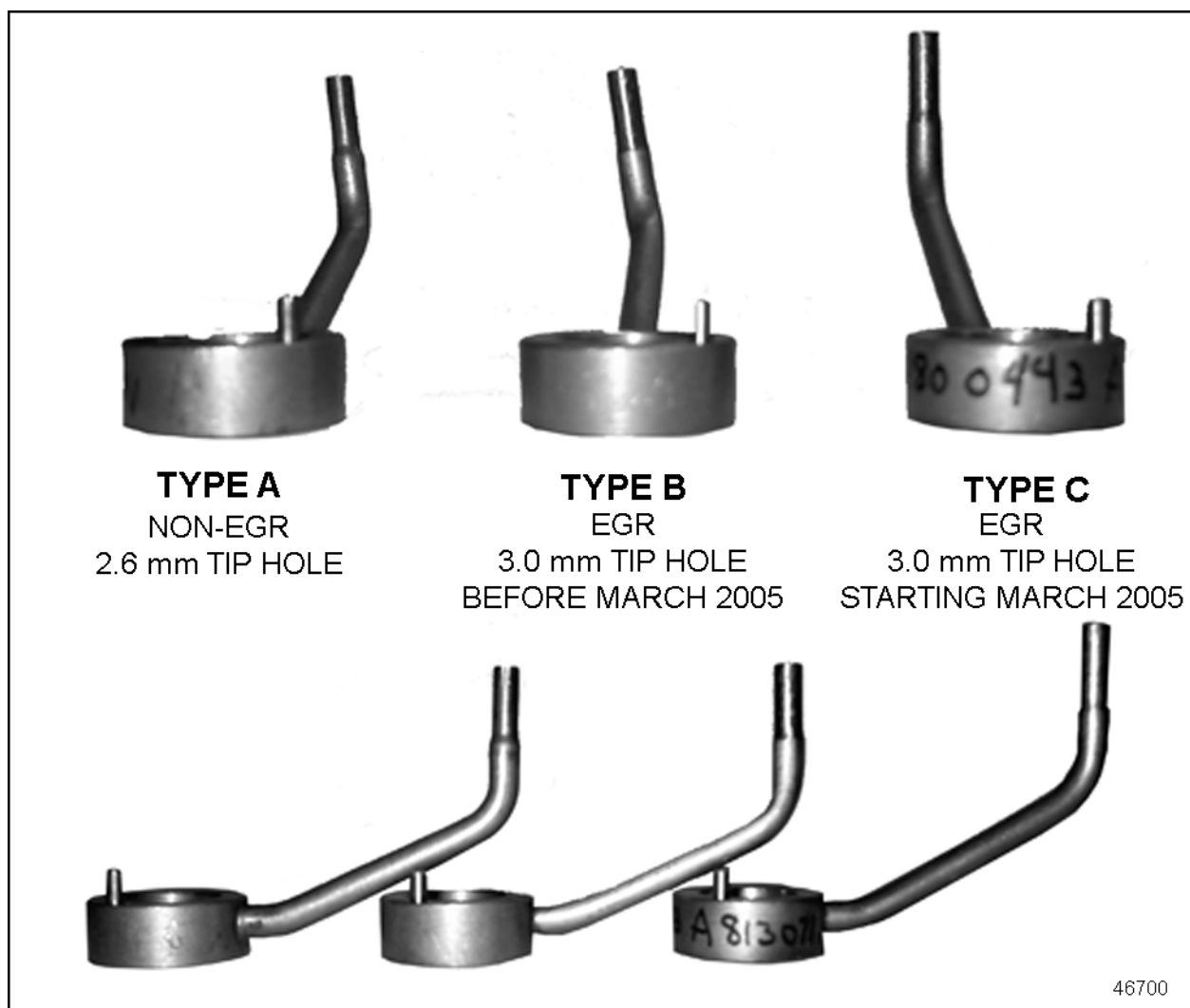
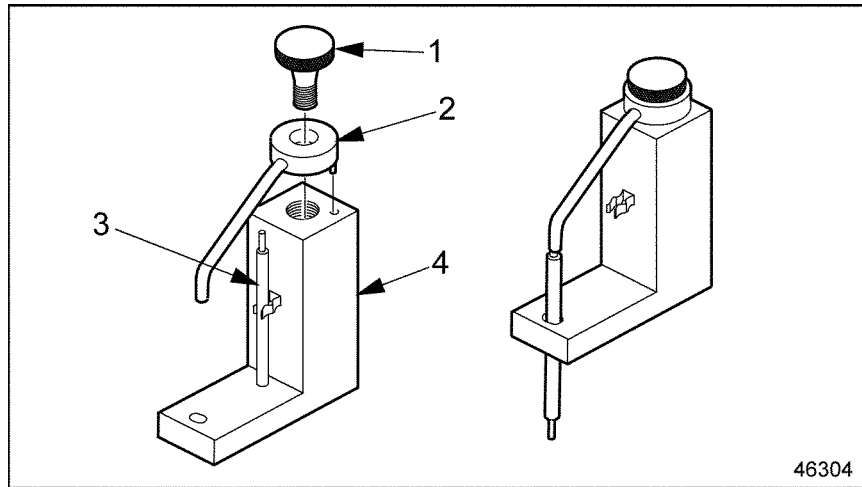


Figure 3-9 **Piston Cooling Nozzles**

4. For non-EGR and EGR engine built before March 2005, check the piston oil spray nozzle(s) using the piston cooling jet tool (J-47301). See Figure 3-10.



- | | |
|----------------------------|-------------------|
| 1. Knurled Bolt | 3. Setting Rod |
| 2. Piston Oil Spray Nozzle | 4. Setting Device |

Figure 3-10 **Checking the Piston Oil Spray Nozzle(s)**

- [a] Secure the setting device (part of toolset J-47301) in a vise with protective jaws.
- [b] Remove the knurled bolt and setting rod from the setting device. Install the piston oil spray nozzle on the setting device. Hand tighten the knurled bolt enough to hold the nozzle firmly.
- [c] Insert the correct end of the setting rod through the base of the setting device and into the tip of the piston oil spray nozzle. If the setting rod will not insert into the tip of the piston oil cooling nozzle, discard the nozzle and replace with a new nozzle.

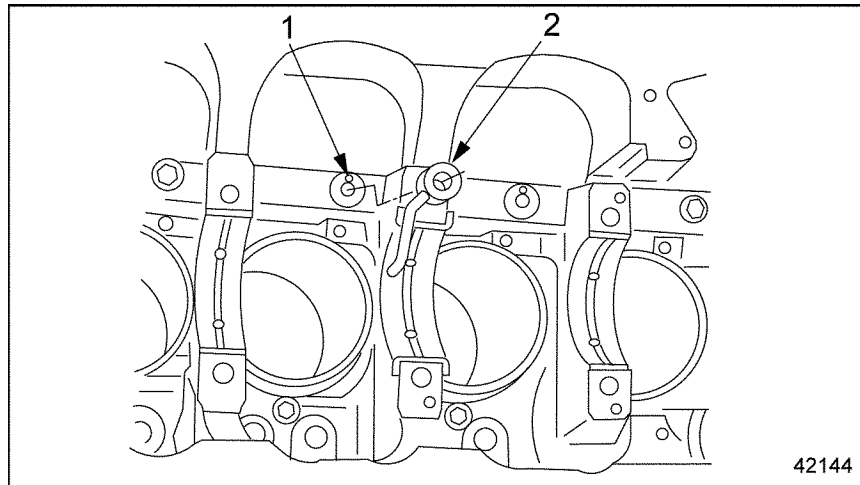
NOTE:

The setting rod is double ended, one end has a diameter of 2.6 mm (0.102 in.) for non-EGR engines and the other end is 3.0 mm (0.118 in.) for EGR engines.

3.2.2 Piston Oil Spray Nozzle(s) Installation

Install the piston oil spray nozzle(s) as follows:

1. Install each piston oil spray nozzle in the block with the locator pin correctly installed. See Figure 3-11. Tighten the hollow-core bolt to 40 N·m (30 lb·ft).



1. Pin Seat

2. Locator Pin

Figure 3-11 Installing the Piston Oil Spray Nozzle(s)

NOTE:

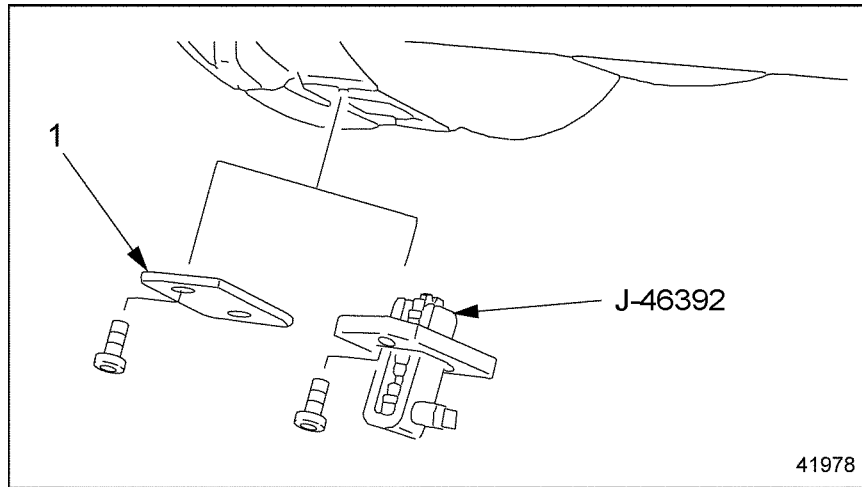
The locator pin on the base of the piston oil spray nozzle must be inserted into the pin seat in the cylinder block until it engages.

NOTICE:

For EGR engines built March 2005 and later, the piston oil spray nozzle must be aligned to the center of the oil lubricating hole in the bottom of the piston. If the nozzle is not properly aligned, inadequate lubrication to the piston will result in the failure of the engine.

2. For EGR engines built March 2005 and later check to ensure that the piston oil spray nozzle(s) are aligned with the oil hole in the base of the piston as follows:
 - [a] Bar the engine until the piston is at bottom dead center and check that the alignment of the oil spray nozzle tip is in the center of the piston oil lubricating hole. The nozzle should be inside the piston oil hole and centered.
 - [b] If the oil spray nozzle does not align in the center of the piston oil lubricating hole or is not inside the oil hole in the piston, replace the nozzle. Do not bend the nozzles to align.
3. Install the oil pan. Refer to section 3.1.2.

4. Remove the engine cranking tool (J-46167) and install the the inspection cover. Torque bolts on cover to 25 N·m (18 lb·ft)See Figure 3-12.



1. Inspection Cover

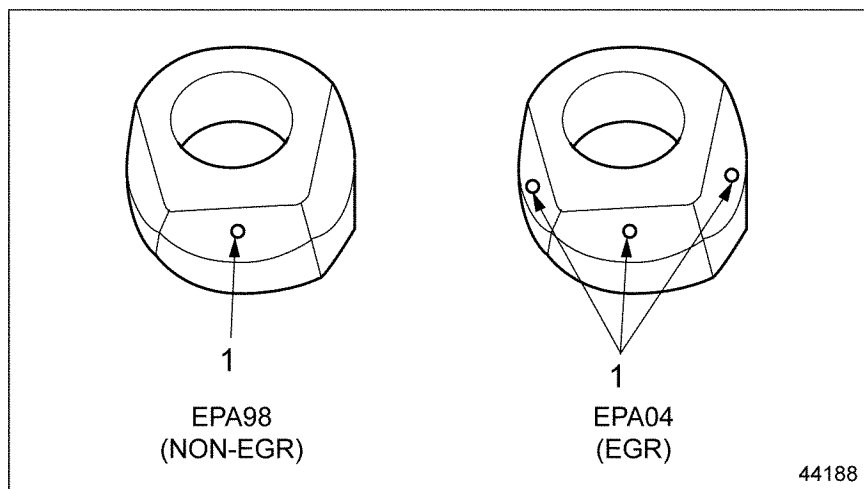
Figure 3-12 **Installing the Engine Cranking Tool**

5. Fill the crankcase to the specified oil level listed in Table 3-4. Do not overfill the crankcase.

3.3 CAMSHAFT LUBRICATION SPRAYER

The six lubrication sprayers are located internally in the upper portion of the cylinder block near the camshaft and have a guide pin for proper location during installation.

The EPA 98 (non-EGR) engine has one drilled oil passage hole in the lubrication sprayer – it is used to spray oil on the injector unit pump camshaft lobe. The lubrication sprayer for the EPA 04 (EGR) engine has three drilled oil passage holes – they are used to spray oil on the camshaft lobes for the injector pump, intake cam followers, and exhaust cam followers. See Figure 3-13.



1. Oil Passages

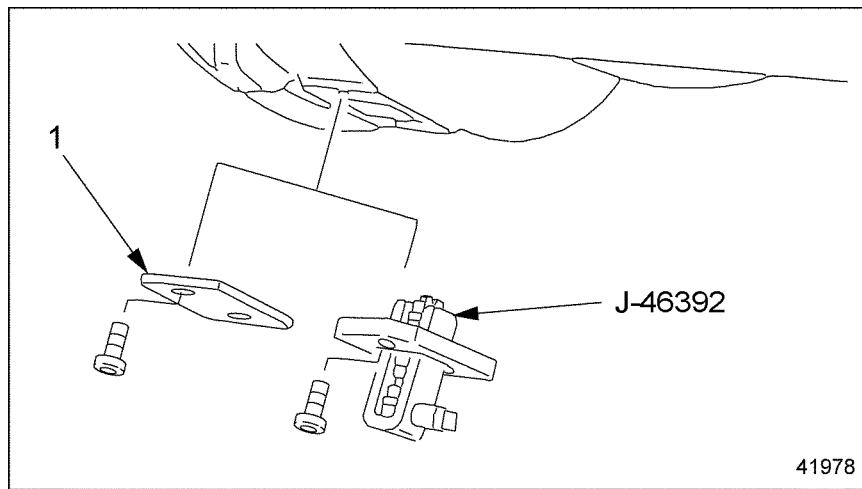
Figure 3-13 Camshaft Lubrication Sprayer

3.3.1 Camshaft Lubrication Sprayer Removal

Remove the camshaft lubrication sprayer(s) as follows:

1. Remove the oil pan. Refer to section 3.1.1.

2. Remove the inspection cover on the flywheel housing and install the engine cranking tool (J-46167). See Figure 3-14. Rotate the crankshaft to gain access to the lubrication sprayer(s).



1. Inspection Cover

Figure 3-14 Installing the Engine cranking Tool

3. Remove the hollow-core bolt holding the sprayer in place.
4. Remove the camshaft lubrication sprayer(s).
5. Clean any clogged holes with solvent.

3.3.2 Camshaft Lubrication Sprayer Installation

Install the camshaft lubrication sprayer(s) as follows:

1. Align the guide pin on the lubrication sprayer with the hole in the block and secure with hollow-core bolt.
2. Torque the hollow-core bolt to 20 N·m (15 lb·ft).
3. Remove the engine cranking tool (J-46167) and install the inspection cover. Torque bolts on cover to 25 N·m (18 lb·ft). See Figure 3-14.
4. Install the oil pan. Refer to section 3.1.2.
5. Fill the crankcase to the specified oil level. Do not overfill the crankcase. The correct oil fill capacity is listed in Table 3-4.

3.4 OIL PUMP AND SUMP PIPE

In the EPA 04 (EGR) engine, there are minor changes to the oil pump. The EGR engine has a higher oil output now. There are larger internal gears compared to the EPA 98 (non-EGR) version which has smaller internal gears. See Figure 3-15.

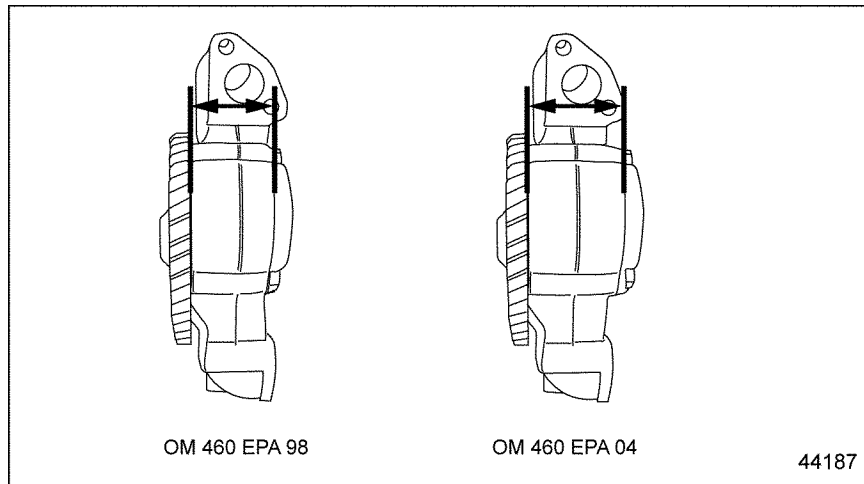


Figure 3-15 Comparison on Oil Pump Internal Gears

The mounting point location on the EGR engine oil sump pipe is 3.0 mm (0.118 in.) longer in length than the non-EGR sump pipe. The removal and installation procedures are the same for the non-EGR and EGR engine. See Figure 3-16.

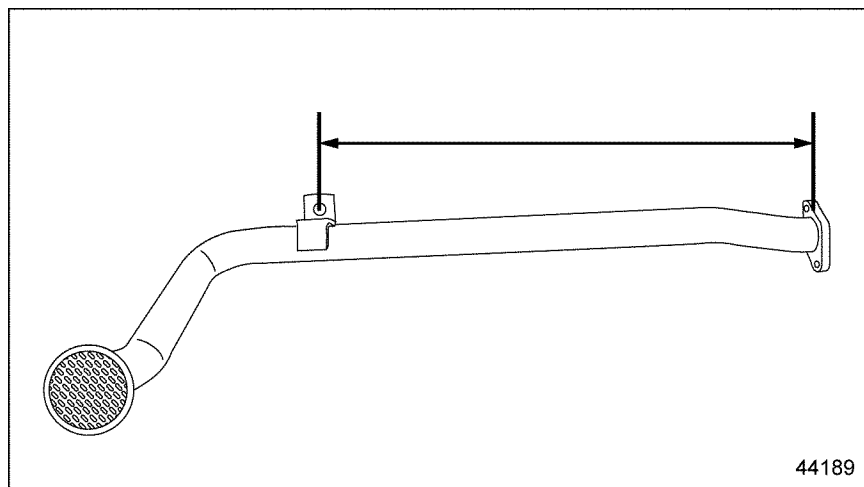


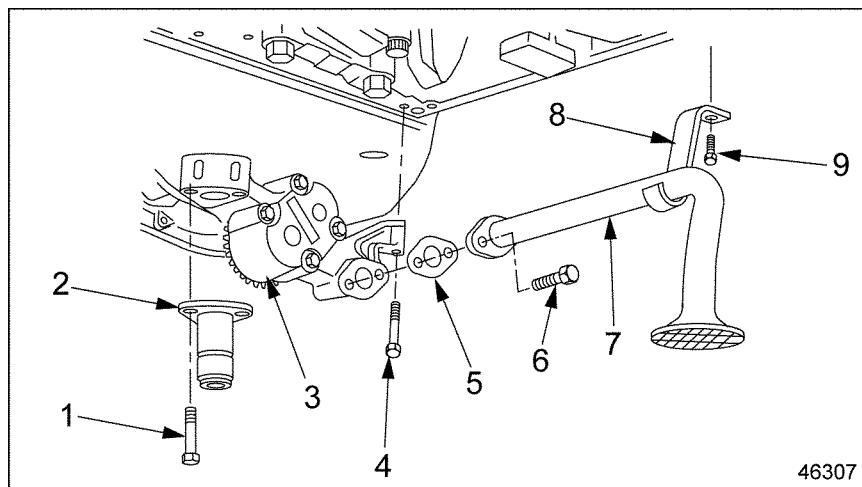
Figure 3-16 Oil Pick Up Tube in the EPA 04 (EGR) Engine

Perform the following procedures for removal of the oil pump.

3.4.1 Oil Pump and Sump Pipe Removal

Remove the oil pump assembly as follows:

1. Remove the oil pan from the cylinder block. Refer to section 3.1.1.
2. Remove the sump pipe from the oil pump. See Figure 3-17.
 - [a] Remove the bolt attaching the sump pipe bracket to the cylinder block.
 - [b] Remove the two bolts attaching the sump pipe to the oil pump. Discard the gasket.
 - [c] Remove the sump pipe and bracket from the oil pump.
3. Remove the bolts attaching the pressure limiting valve to the oil pump and lower edge of the cylinder block. Remove the pressure limiting valve from the oil pump. See Figure 3-17.



- | | |
|----------------------------|----------------------------|
| 1. Valve Mounting Bolt | 6. Sump Pipe Mounting Bolt |
| 2. Pressure Limiting Valve | 7. Sump Pipe |
| 3. Oil Pump | 8. Bracket |
| 4. Oil Pump Mounting Bolt | 9. Bracket Mounting Bolt |
| 5. Gasket | |

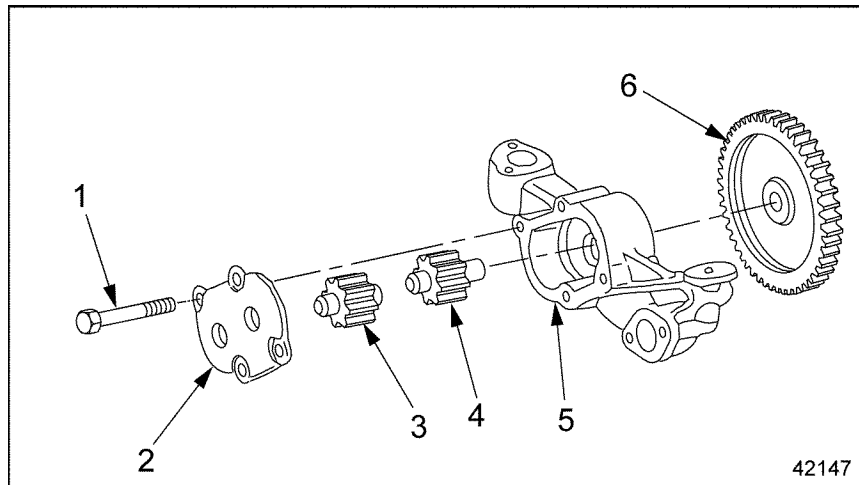
Figure 3-17 Oil Pump and Sump Pipe Removal

4. Remove the bolt attaching the oil pump to the cylinder block. Remove the oil pump from the the cylinder block. See Figure 3-17.
5. Thoroughly clean the contact surfaces of the oil pump and cylinder block.

3.4.2 Oil Pump Disassembly

Disassemble the oil pump unit as follows:

1. Remove the oil pump from the cylinder block. Refer to section 3.4.1.
2. Remove the face plate mounting bolts and remove the face plate from the oil pump housing. See Figure 3-18.



- | | |
|-----------------------------|--------------------|
| 1. Face Plate Mounting Bolt | 4. Pump Drive Gear |
| 2. Face Plate | 5. Pump Housing |
| 3. Idler Gear | 6. Drive Wheel |

Figure 3-18 Oil Pump (exploded view)

3. Remove the idler gear from the pump housing.
4. Using an appropriate drift, press the drive wheel off the pump drive gear.
5. Remove the pump drive gear from the pump housing.
6. Inspect the idler gear, pump drive gear, face plate, and pump housing for damage and excessive wear. Replace any worn or damaged parts.

NOTE:

If either the idler gear or pump drive gear needs replacing, replace both gears as a set.

7. Check the idler and pump drive gears. Check their seats in the pump housing and face plate. Listed in Table 3-1 are the acceptable limits.

Description	mm (inch)
Diameter of Shaft Bore (in pump housing and face plate)	22.000-22.021 (0.8661-0.8670)
Diameter of Idler Gear and Pump Drive Gear Shaft	21.93-21.94 (0.8634-0.8638)
Clearance of Pump/Idler Gear to Walls of Pump Housing	0.030-0.122 (0.0012-0.0048)
Gear Backlash (clearance between gear cogs)	0.312-0.476 (0.0123-0.0187)

Table 3-1 Oil Pump Inspection Limits

- [a] In the pump housing, measure the diameter of both gear shaft bores, the idler gear seat and the pump drive gear seat. If the measurements are not within acceptable limits, replace the pump housing.
- [b] Measure the diameter of both shaft bores in the face plate. If the measurements are not within acceptable limits, replace the face plate.
- [c] Measure the diameter of the pump drive gear shaft and the idler gear shaft. If the measurements are not within acceptable limits, replace both gears as a set.
- [d] Using a feeler gauge, measure the clearance between the gears and the pump housing wall. If the measurements are not within acceptable limits, replace both gears as a set.
- [e] Using a feeler gauge, measure gear backlash (the clearance between two adjacent cogs on different gears). If the measurements are not within acceptable limits, replace both gears as a set.

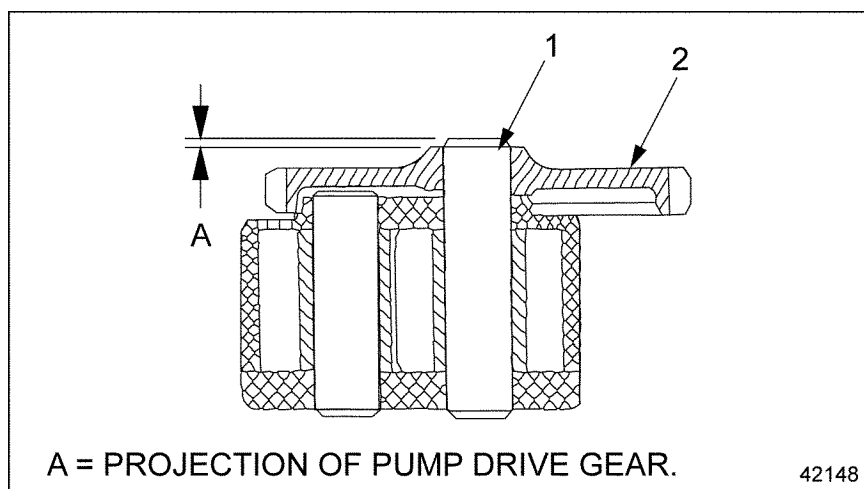
3.4.3 Oil Pump Assembly

Assemble the oil pump unit as follows:

 WARNING: BURNS
To avoid injury from burning, use lifting tools and heat-resistant gloves when handling heated components.

1. Heat the drive wheel to approximately 80°C (176°F) in a hot water tank.

2. Seat the pump drive gear in the pump housing. Using an appropriate drift, press in the heated drive wheel until the pump drive gear projects slightly past the top of the drive wheel. See Figure 3-19.



1. Pump Drive Gear

2. Drive Wheel

Figure 3-19 Positioning the Drive Wheel on the Pump Drive Gear

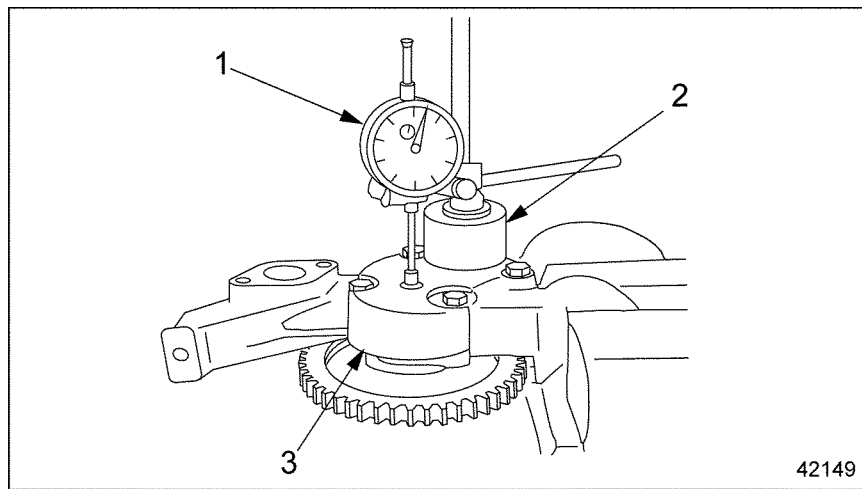
3. Using a feeler gauge, measure the projection of the pump drive gear. Adjust the position of the pump drive gear until the projection equals 0.5 mm (0.02 inch), as listed in Table 3-2.

Description	mm (inch)
Projection of Pump Drive Gear	0.5 (0.02)
Pump/Idler Gear End Play	0.050-0.128 (0.0020-0.0050)

Table 3-2 Oil Pump Installation Specifications

4. Seat the idler gear in the pump housing.
5. Install the face plate on the pump housing. Tighten the mounting bolts to 25 N·m (18 lb·ft).

6. Using a dial gauge, measure the end play of the pump drive gear and idler gear against the walls of the pump housing. See Figure 3-20 for set-up and listed in Table 3-2 are the specifications.



1. Dial Gauge

3. Oil Pump

2. Support

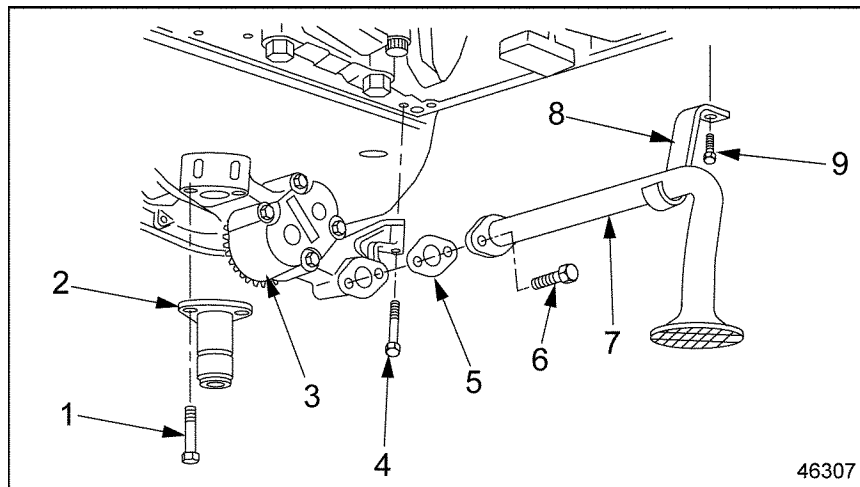
Figure 3-20 Measuring the Clearance of the Pump Drive Gears

- [a] Secure the assembled oil pump in a vise, with the face plate pointing up.
 - [b] Rest the dial gauge support on the face plate.
 - [c] Set up the dial gauge so that the feeler on the end of the gauge touches the exposed end of the pump drive gear with some preload.
 - [d] Force the pump drive gear downward as far as it will go.
 - [e] At this position, adjust the scale of the dial gauge to "0" (zero).
 - [f] Now force the pump drive gear upward as far as it will go. Read the measurement on the dial gauge and make sure it conforms to the range listed in Table 3-2. Replace the pump, if necessary.
 - [g] Repeat this procedure for the idler gear.
7. Install the oil pump in the cylinder block. Refer to section 3.4.4.

3.4.4 Oil Pump and Sump Pipe Installation

Install the oil pump and Sump Pipe as follows:

1. Coat the contact surface between the block and the oil pump with Loctite® 574.
2. Position the oil pump on the cylinder block. Make sure the teeth on the drive wheel of the oil pump mesh with the teeth of the crankshaft drive gear. Tighten the oil pump mounting bolt to 35 N·m (26 lb·ft). See Figure 3-21.



- | | |
|----------------------------|----------------------------|
| 1. Valve Mounting Bolt | 6. Sump Pipe Mounting Bolt |
| 2. Pressure Limiting Valve | 7. Sump Pipe |
| 3. Oil Pump | 8. Bracket |
| 4. Oil Pump Mounting Bolt | 9. Bracket Mounting Bolt |
| 5. Gasket | |

Figure 3-21 Oil Pump and Sump Pipe Installation

NOTE:

It may be necessary to rock the pump counterclockwise so the teeth of the drive wheel can properly align with the crankshaft drive gear.

3. Check the backlash between the oil pump drive and the crankshaft gear. The specification is 0.077 – 0.333 mm (0.003 – 0.131 in.).
4. Install the pressure limiting valve on the oil pump. Tighten the valve mounting bolt to 35 N·m (26 lb·ft).
5. Install the sump pipe to the oil pump. Tighten all mounting bolts to 25 N·m (18 lb·ft). See Figure 3-21.
 - [a] Install the sump pipe bracket on the cylinder block.
 - [b] Install the sump pipe, with a new gasket, on the oil pump.
6. Install the oil pan with a new gasket. Refer to section 3.1.2.

7. Fill the engine oil circuit. The correct oil fill capacity is listed in Table 3-4.

**WARNING:****PERSONAL INJURY**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- ☐ **Always start and operate an engine in a well ventilated area.**
- ☐ **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- ☐ **Do not modify or tamper with the exhaust system or emission control system.**

8. Start the engine and check for leaks.
9. Check the engine oil level and add oil if necessary.

3.5 OIL FILTER

■ Perform the following procedures for removal and installation of the oil filter.

3.5.1 Oil Filter Element Replacement

Replace the oil filter element as follows:

1. Clean the outside of the oil filter housing, then unscrew the oil filter cap from the housing. See Figure 3-22.

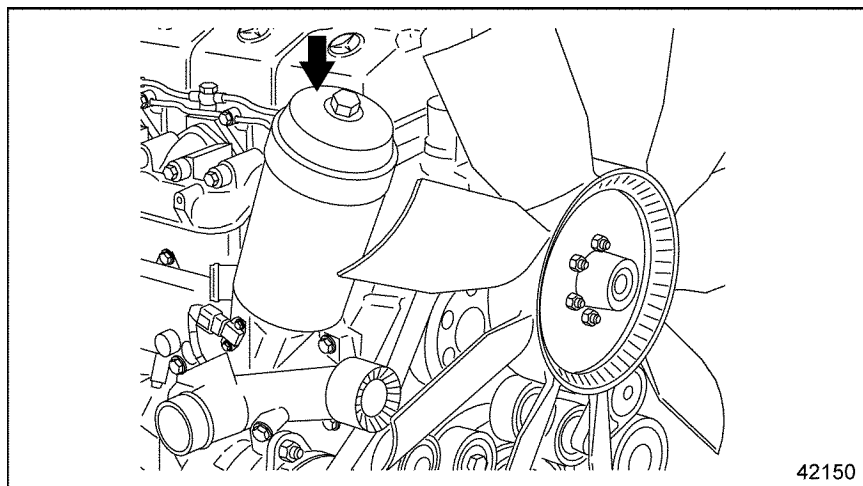
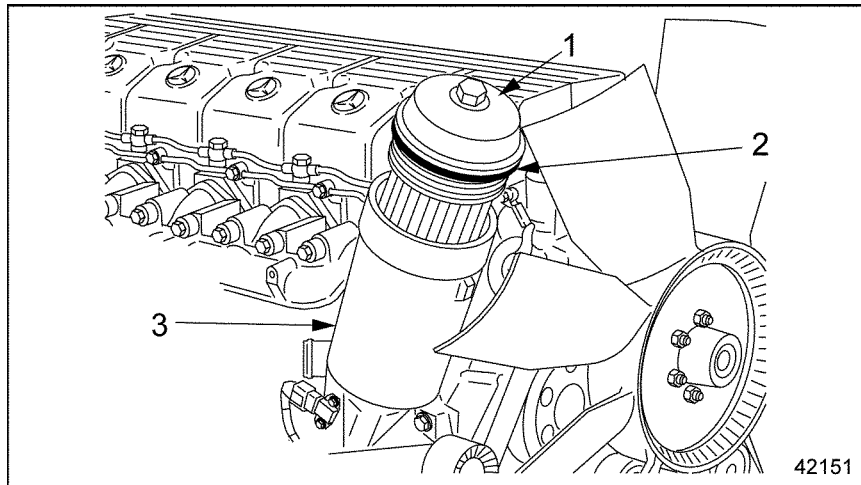


Figure 3-22 Oil Filter Cap

NOTE:

Use care to prevent foreign objects from entering the filter housing.

2. Unscrew the cap and filter and allow the oil to drain into the housing. After draining, remove the assembly from the housing. See Figure 3-23.



1. Oil Filter Cap

3. Oil Filter Housing

2. O-ring

Figure 3-23 Oil Filter Element Replacement

3. Remove the element by pressing and twisting the side and detaching it from the cap.
4. Remove the oil filter O-ring and discard it. Lightly grease a new O-ring with engine oil and install it.
5. Insert a new filter element into the housing.
6. Install the cap on the filter and tighten the cap nut to 25 N·m (18 lb·ft).

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- ☐ **Do not modify or tamper with the exhaust system or emission control system.**

7. Start the engine and check for leaks.
8. Check the engine oil level and add oil if necessary.

3.6 OIL HEAT EXCHANGER/FILTER HOUSING

Perform the following procedures for removal and installation of the oil heat exchanger/filter housing.

3.6.1 Oil Heat Exchanger/Filter Housing Removal

Remove the oil heat exchanger/filter housing as follows:



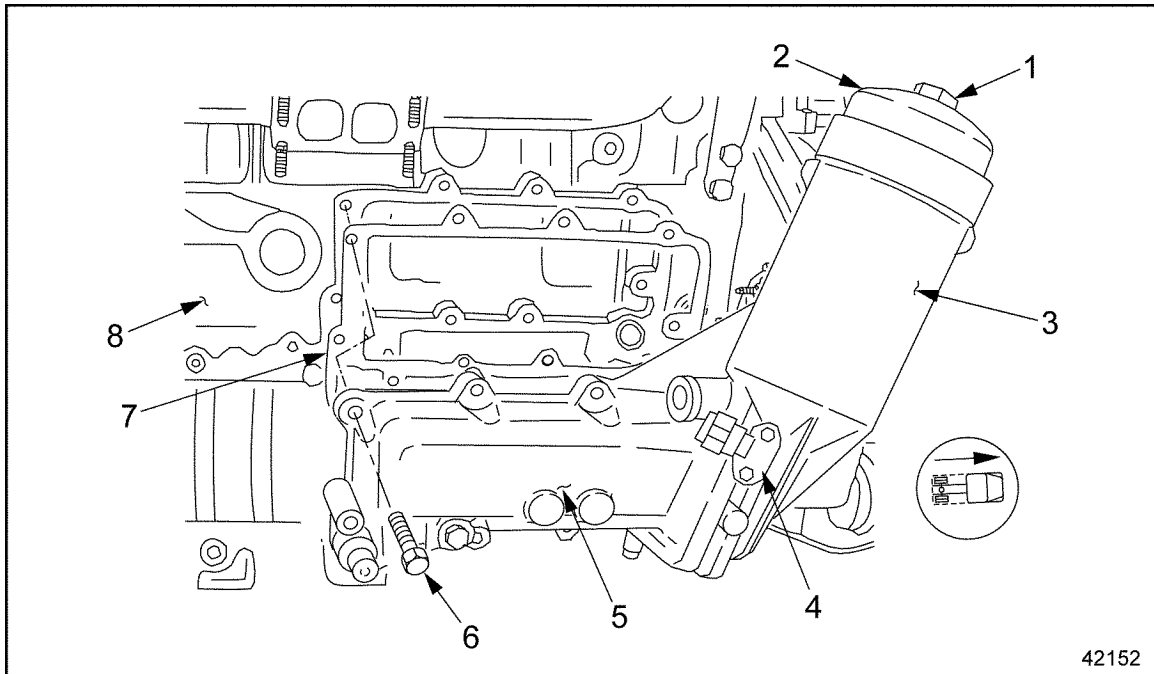
WARNING:

HOT COOLANT

To avoid scalding from the expulsion of hot coolant, never remove the cooling system pressure cap while the engine is at operating temperature. Wear adequate protective clothing (face shield, rubber gloves, apron, and boots). Remove the cap slowly to relieve pressure.

1. When the engine is cool, drain the coolant from the radiator.
2. Remove the turbocharger from the engine.
3. Disconnect the coolant pump shunt line from the coolant pump inlet pipe and move it out of the way.
4. Remove the oil filter cap. Inspect the O-ring and filter for damage and replace them if necessary. Drain the oil remaining in the filter into a clean container.
5. Disconnect the wiring harness from the oil pressure/temperature sensor.

6. Remove the oil heat exchanger/filter housing from the cylinder block. See Figure 3-24. Catch any oil that drains out in a clean container. Discard the gasket and set aside the housing bolts for later installation.



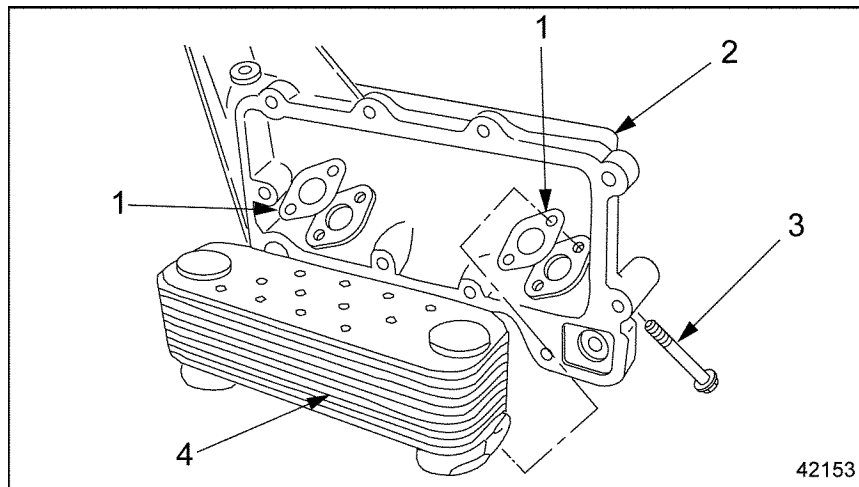
- | | |
|------------------------------------|--------------------------------------|
| 1. Oil Filter Cap Nut | 5. Oil Heat Exchanger/Filter Housing |
| 2. Oil Filter Cap | 6. Housing Bolt |
| 3. Oil Filter Housing | 7. Gasket |
| 4. Oil Pressure/Temperature Sensor | 8. Cylinder Block |

Figure 3-24 Oil Heat Exchanger/Filter Housing Removal

NOTE:

The oil filter housing and the heat exchanger housing are part of the same casting.

7. Remove the oil heat exchanger from the oil filter/heat exchanger housing. Discard the gaskets and save the heat exchanger bolts for later installation. See Figure 3-25.



1. Gasket

2. Oil Filter/Heat Exchanger Housing

3. Oil Heat Exchanger Bolt

4. Oil Heat Exchanger

Figure 3-25 Oil Heat Exchanger Assembly (typical)

8. Remove the oil pressure/temperature sensor from the oil heat exchanger/filter housing. Refer to section 3.7.1.

3.6.2 Oil Heat Exchanger/Filter Housing Installation

Install the oil heat exchanger/filter housing as follows:

1. Check the oil heat exchanger and the inside of the heat exchanger housing for corrosion, contamination by metal particles, or abrasive material, such as sand.
 - [a] If corrosion is found, clean or replace the oil heat exchanger, as necessary.
 - [b] Clean the mating surfaces of the oil heat exchanger and heat exchanger housing. Remove any bits of adhering gasket material.
2. Install the oil heat exchanger and new gaskets on the heat oil exchanger/filter housing. Tighten the heat exchanger bolts to 25 N·m (18 lb·ft).

3. Install the oil filter/heat exchanger housing on the cylinder block. Install the housing bolts and tighten them in the order shown in see Figure 3-26. Tighten each bolt to 60 N·m (44 lb·ft).

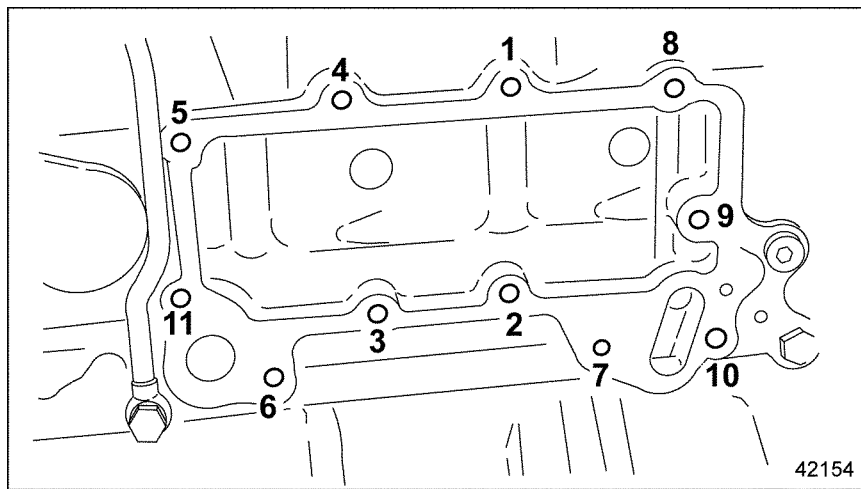
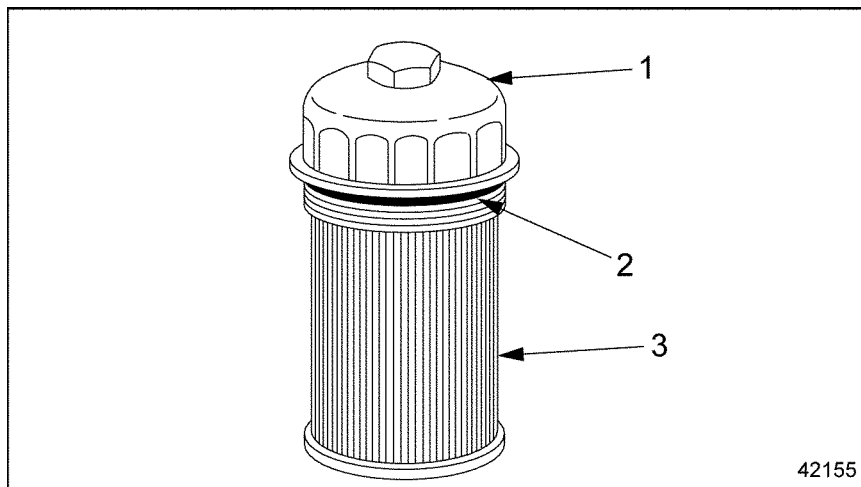


Figure 3-26 Tightening Pattern, Heat Exchanger/Oil Filter Housing Bolts

- [a] Clean the mating surfaces of the oil heat exchanger/filter housing and the cylinder block. Remove any bits of adhering gasket material.
- [b] Replace the oil heat exchanger/filter housing gasket.
4. Install a new filter element and O-ring in the oil filter housing. See Figure 3-27.



1. Oil Filter Cap
2. O-ring

3. Oil Filter Element

Figure 3-27 Oil Filter Assembly

5. Install the oil filter cap. Tighten the cap nut to 25 N·m (18 lb·ft).

6. Install the oil pressure/temperature sensor on the oil heat exchanger/filter housing. Refer to section 3.7.2.
7. Connect the wiring harness to the oil pressure/temperature sensor.
8. Install the turbocharger on the engine. Refer to section 6.3.3.
9. Connect the coolant pump shunt line to the coolant pump inlet pipe.
10. Fill the cooling system. Refer to section 4.1.1.

**WARNING:****PERSONAL INJURY**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- ☐ **Always start and operate an engine in a well ventilated area.**
- ☐ **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- ☐ **Do not modify or tamper with the exhaust system or emission control system.**

11. Start the engine. Check the gauge for the correct oil pressure; check the oil lubrication system and the coolant pump inlet pipe for leaks. The correct oil pressures are listed in Table 3-3.

Engine Speed	Minimum Pressure
At idling rpm	50 kPa (7 psi)
At maximum rpm	250 kPa (36 psi)

Table 3-3 Engine Oil Pressures

3.7 OIL PRESSURE/TEMPERATURE SENSOR

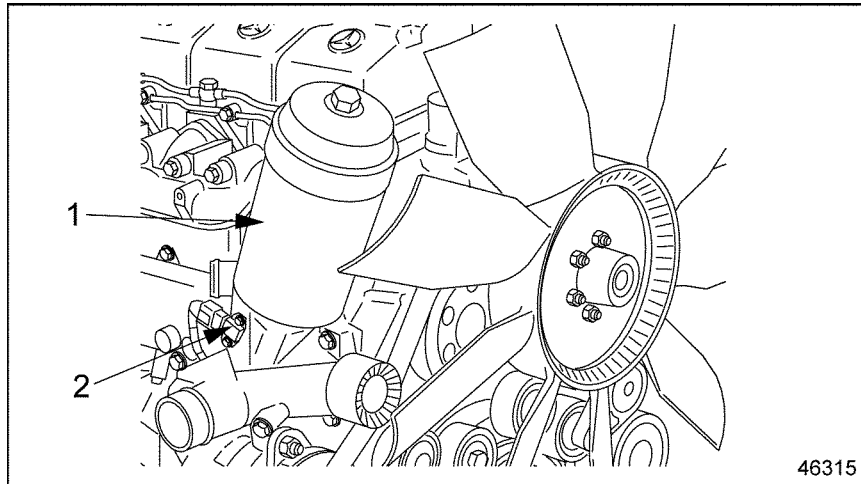
The oil pressure/temperature sensor is located on the oil filter housing.

Perform the following procedures for removal and installation of the oil pressure/temperature sensor.

3.7.1 Oil Pressure/Temperature Sensor Removal

Removal the oil pressure and temperature sensor as follows:

1. Loosen the oil filter cap. Lift up the cap and filter to allow the oil to drain. Inspect the O-ring for damage and replace if necessary.
2. Disconnect the wiring connector from the oil pressure/temperature sensor. See Figure 3-28.



1. Oil Filter

2. Oil Pressure/Temperature Sensor

Figure 3-28 Oil Pressure/Temperature Sensor Location

3. Remove the two bolts securing the oil pressure/temperature sensor to the oil filter.

3.7.2 Oil Pressure/Temperature Sensor Installation

Install the oil pressure/temperature sensor as follows:

1. Position the oil pressure/temperature sensor and install the mounting screws. Tighten the fasteners 8 N·m (6 lb·ft).
2. Connect the wiring harness at the oil pressure/temperature sensor.
3. Using a new O-ring (if necessary), install the oil filter cap. Tighten the nut 25 N·m (18 lb·ft).

**WARNING:****PERSONAL INJURY**

Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

- ☐ **Always start and operate an engine in a well ventilated area.**
- ☐ **If operating an engine in an enclosed area, vent the exhaust to the outside.**
- ☐ **Do not modify or tamper with the exhaust system or emission control system.**

4. Start the engine. Check the gauge for the correct oil pressure listed in Table 3-9; and check the lubrication system for leaks. .
5. Check and add engine oil as needed.

3.A ADDITIONAL INFORMATION

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Oil Pump	3-38
Oil Heat Exchanger	3-38

SPECIFICATIONS

This section contains the specifications for servicing the engine.

Lubrication System

Listed in Table 3-4 is the lubricating oil capacity for the engine. The lubrication system torque values are listed in Table 3-5 and listed in Table 3-6.

Description	All Engines
Oil Pan Capacity	40 L (42 quarts)
Engine Oil Fill Capacity *	43.5 L (46.0 quarts)

*In standard oil pan, including oil filter.

Table 3-4 Lubricating Oil Capacity

Description	N·m (lb·ft)
Adaptor Nut (to oil pan)	50 (37)
Dipstick Guide Tube Fitting (to adaptor)	20 (15)
Oil Heat Exchanger/Filter Housing Bolts (to block)	60 (44)
Oil Heat Exchanger Bolts (heat exchanger to housing)	25-30 (18-22)
Oil Fill Tube Bolt (to oil pan)	25 (18)
Oil Fill Tube Retainer Bolt (to block)	25 (18)
Oil Filter Cap	25 (18)
Oil Pan Drain Plug	80 (59)
Oil Pan Bolts (to block)	35 (26)
Oil Pressure/Temperature Sensor Mounting Screws	8-10 (6-7)
Oil Pump Face Plate Mounting Bolts (to oil pump housing)	25 (18)
Oil Pump Mounting Bolt (to block)	35 (26)
Oil Spray Nozzle Hollow-Core Bolt	40 (30)
Pressure Limiting Valve Bolts (to block)	35 (26)
Sump Pipe Bracket to Crankcase Bolt	25 (18)
Sump Pipe Mounting Bolt (to oil pump)	25 (18)

Table 3-5 Torque Values

Description	Torque, N·m (lb·ft)
Injector Unit Pump (IUP) Lubricator Bolt	20 (15)
Main Oil Gallery - Engine Block Rear bottom plug - M26 x 1.5	150 (110)
Main Oil Gallery - Inner Plug - M22 x 1.5	50 (37)
Main Oil Gallery - Engine Block Rear Top Plug - M24 x 1.5	120 (89)
Main Oil Gallery - Engine Block Front Plug - M22 X 1.5	100 (74)
Main Oil Gallery - Engine Right Hand Side Top Plug before the Oil Filter Housing - M18 x 1.5	60 (44)
Main Oil Gallery - Engine Right Hand Side Bottom Plug before the Oil Filter Housing - M16 x 1.5	60 (44)
Main Oil Gallery - Engine Right Hand Side Bottom Plug after the Oil Filter Housing - M16 x 1.5	60 (44)

Table 3-6 Torque Values

Oil Pump

The oil pump inspection limits are listed in Table 3-7. Listed in Table 3-8 are the oil pump installation specifications.

Description	mm (inch)
Diameter of Shaft Seat (in pump housing and face plate)	22.000-22.021 (0.8661-0.8670)
Diameter of Idler Gear and Pump Drive Gear Shaft	21.93-21.94 (0.8634-0.8638)
Clearance of Pump/Idler Gear to Walls of Pump Housing	0.030-0.122 (0.0012-0.0048)
Oil Pump Gear Backlash (clearance between gear cogs)	0.312-0.476 (0.0123-0.0187)

Table 3-7 Oil Pump Inspection Limits

Description	mm (inch)
Projection of Pump Drive Gear	0.5 (0.02)
Pump/Idler Gear End Play	0.050-0.128 (0.0020-0.005)
Backlash of Oil Pump Drive Gear and Crankshaft Gear	0.077-0.333 (0.0030-0.1311)

Table 3-8 Oil Pump Installation Specifications

Oil Heat Exchanger

The minimum engine oil pressure is listed in Table 3-9.

Engine Speed	Minimum Pressure
At idling rpm	50 kPa (7 psi)
At maximum rpm	250 kPa (36 psi)

Table 3-9 Engine Oil Pressures